

AMENDMENTS TO THE CLAIMS:

Complete Listing of Claims

- 1 Claim 1. (currently amended) A microcontroller integrated circuit (IC)
2 comprising:
3 a program memory for storing a program to be executed;
4 a program counter coupled to the program memory for selecting address
5 locations in said memory;
6 a program counter copy register for storing a program memory address
7 pointed to by said program counter as a return address from a debug monitor
8 routine;
9 instruction execution circuitry coupled to the program memory for
10 executing instructions received from said memory;
11 a breakpoint address register for storing a breakpoint address;
12 address compare circuitry for comparing a value in said program counter
13 to a value in said breakpoint address register, said compare circuitry providing a
14 breakpoint signal upon detection of a valid breakpoint address comparison; and
15 a multiplexer interposed between said program memory and said program
16 execution circuitry, said multiplexer comprising circuitry for inserting a debug
17 instruction into the instruction execution circuitry upon receipt of said breakpoint
18 signal, wherein said debug instruction is substituted for an instruction in a
19 program memory address pointed to by said program counter.

1 Claim 2. (original) The microcontroller IC of claim 1, further comprising:
2 a stack pointer register;
3 a stack breakpoint register for storing a stack trap address;
4 stack pointer compare circuitry for comparing a value in said stack pointer
5 register to a value in said stack breakpoint register, said stack pointer compare
6 circuitry providing a stack trap signal upon detection of a valid stack pointer
7 address comparison; and
8 wherein said multiplexer inserts said debug instruction into the instruction
9 execution circuitry upon receipt of said stack trap signal.

1 Claim 3. (original) The microcontroller IC of claim 2, wherein said valid stack
2 pointer address comparison is selected from the group consisting of: said value
3 in said stack pointer register being equal to said value in said stack breakpoint
4 register, said value in said stack pointer register being greater than said value in
5 said stack breakpoint register, said value in said stack pointer register being less
6 than said value in said stack breakpoint register, and combinations thereof.

1 Claim 4. (original) The microcontroller IC of claim 1, further comprising single
2 step circuitry directing said multiplexer circuitry to insert said debug instruction
3 into the instruction execution circuitry after the execution of each instruction of an
4 application program.

1 Claim 5. (original) The microcontroller IC of claim 1, wherein said debug
2 instruction is a long jump instruction to a debug monitor routine.

Claim 6 (canceled)

1 Claim 7. (original) The microcontroller IC of claim 1, wherein said address
2 comparison circuitry further comprises memory bank comparison circuitry for
3 detecting a specific bank access in addition to said breakpoint address.

1 Claim 8. (original) An embedded microcontroller apparatus comprising:
2 a circuit board embedded in the apparatus;
3 a microcontroller integrated circuit disposed on said circuit board,
4 including :
5 a program memory for storing a program to be executed,
6 a program counter coupled to the program memory for selecting address
7 locations in said memory,
8 a program counter copy register for storing a program memory address
9 pointed to by said program counter as a return address from a debug monitor
10 routine, and
11 debug circuitry disposed on said microcontroller integrated circuit, said
12 debug circuitry comprising
13 compare circuitry for comparing a breakpoint address to instruction
14 fetch addresses in said program memory, said compare circuitry
15 generating a breakpoint signal indicating a valid address compare; and
16 multiplexer circuitry coupled to said compare circuitry, said
17 multiplexer circuitry, upon receiving said breakpoint signal, substituting a
18 debug program instruction for execution by the microcontroller in place of
19 a standard instruction fetched from program memory.

1 Claim 9. (original) The embedded microcontroller apparatus of claim 8,
2 wherein said apparatus is a universal serial bus controller.

1 Claim 10. (original) The embedded microcontroller apparatus of claim 8,
2 wherein said microcontroller further comprises a stack pointer register, and said
3 debug circuitry further comprises:
4 a stack breakpoint register for storing a stack trap address; and
5 stack pointer compare circuitry for comparing a value in said stack pointer
6 register to a value in said stack breakpoint register, said stack pointer compare
7 circuitry providing a stack trap signal upon detection of a valid stack pointer
8 address comparison; wherein said multiplexer substitutes said debug program
9 instruction for execution by said microcontroller upon receiving said stack trap
10 signal.

1 Claim 11. (original) The embedded microcontroller apparatus of claim 10,
2 wherein said valid stack pointer address comparison is selected from the group
3 consisting of: said value in said stack pointer register being equal to said value in
4 said stack breakpoint register, said value in said stack pointer register being
5 greater than said value in said stack breakpoint register, said value in said stack
6 pointer register being less than said value in said stack breakpoint register, and
7 combinations thereof.

1 Claim 12. (original) The embedded microcontroller apparatus of claim 8, said
2 debug circuitry further comprising single step circuitry directing said multiplexer
3 circuitry to substitute said debug program instruction for execution by said
4 microcontroller after the execution of each standard instruction fetched from
5 program memory.

1 Claim 13. (original) The embedded microcontroller apparatus of claim 8,
2 wherein said debug program instruction is a long jump instruction to a debug
3 monitor routine.

Claim 14 (canceled)

1 Claim 15. (currently amended) A method of debugging a microcontroller
2 integrated circuit, said method comprising:
3 storing a breakpoint address in a hardware register on said microcontroller
4 integrated circuit;
5 executing an application program from program memory by said
6 microcontroller;
7 comparing application program instruction addresses to said breakpoint
8 address;
9 halting execution of said application program upon detection of an
10 instruction fetch from a memory address equal to said breakpoint address;
11 storing said memory address in a program counter copy register, wherein
12 said address is reloaded into said program counter after execution of said debug
13 routine;
14 substituting a jump instruction to a debug program for said instruction
15 fetched from said memory address; and
16 executing said debug program.

1 Claim 16. (original) The method of claim 15, further comprising:
2 storing a stack trap address in a stack breakpoint hardware register on
3 said microcontroller;
4 comparing stack pointer addresses to said stack breakpoint address; and
5 upon detection of a valid stack pointer address comparison, performing
6 said halting execution, said substituting said jump instruction, and said executing
7 said debug program steps.

1 Claim 17. (original) The method of claim 16, wherein said valid stack pointer
2 address comparison is selected from the group consisting of: said stack pointer
3 address being equal to said stack breakpoint address, said stack pointer address
4 being greater than said stack breakpoint address, said stack pointer address
5 being less than said stack breakpoint address, and combinations thereof.

1 Claim 18. (original) The method of claim 15, said executing said debug program
2 comprising:
3 providing status information to external circuitry; and
4 receiving new breakpoint address information.

Claim 19 (canceled)

1 Claim 20. (currently amended) The method of claim 15 49, further comprising
2 pushing the address stored in the program counter copy register onto a stack
3 and executing a return to said application program at a location pointed to by
4 said memory address.